Nutritional Deficiency Disorders

Boralkar R.¹*, Sharma A.², Gaikwad S.³, Dongare T.⁴

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¹ Rucha Boralkar, Student, Food technology, MIT ADT university, Pune, Maharashtra, India.
² Abhishek Sharma, Armed Forces Medical College, Pune, AFMC Pune, , Pune, Maharashtra, India.
³ Sandip Gaikwad, Professor, Food technology, MIT ADT university, Pune, Maharashtra, India.
⁴ Tejas Dongare, Student, Food technology, MIT ADT university, Pune, Maharashtra, India.

Nutrients are the most essential factors in the human body responsible for growth. Carbohydrates, fats, proteins, minerals, and vitamins are examples of nutrients, water and fiber are also some of them. All these nutrients have to be present in the meal in specific percentages. The imbalance of these percentages leads to the lack of some nutrients and overconsumption of others. This leads to certain negative health conditions.

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Introduction

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Current scenario

India has a long history of malnutrition. Developing countries are the hotspots for deficiency diseases due to persistent hunger arising from poverty. Women and children are seen to be more deficient than men everywhere (1) The most common micronutrient deficiency is anaemia; it affects 50 to 60 per cent children below the age of 6 and women. A survey carried out by NNMB (ICMR) in eight states of India showed that 67 to 78 per cent of preschool children, adolescent girls, pregnant and lactating women from the rural areas had anaemia. Micronutrient deficiencies are detrimental for the country as it costs around 0.8-2.5 per cent of GDP. The year 2016 reported 0.5 per cent of total deaths in India due to deficiency diseases (2) Extensive cases of low birth weight, high mortality in children and poor maternal nutrition are major concerns in India (3)

India has a lot of nutrition programs implemented in schools: the Mid-Day meals, Integrated Child Development Services; in spite of these the nutritional health of the country remains a huge concern. In 2017, 59.7% Indian children below the age of 5 were found to be anaemic, 39.3% were found to be stunted, 32.7% underweight and 21.4% had low birth weight. 54.4% Indian women (age 15-49 years), in the same study, were reported anaemic. Of the total reported deaths of children under 5 years of age, 68.2% were due to malnutrition. India has definitely made a progress in the direction of reduction of malnutrition from 1990 to 2017, but it isn’t enough to reach the targets set by the National Nutrition Mission for 2022 set by the World Health Organization.

Need for nutrition

Nutrition is the basic need of all human beings and animals living on earth. All the processes that lead up to the organism ultimately absorbing nutrients from food refers to nutrition. Nutrients are essential for the body to work properly. The lack of nutrients or the imbalance of nutrients in the body leads to various diseases, disabilities and weakness (4)

Figure 1: Nutritional well-being for all

Proper nutrition treats and prevents nutrition deficiencies. But the excess or imbalance of any nutrients can cause problems to the body as it cannot control and regulate the absorption and storage of nutrients (4) Recent advances in the field have helped us understand metabolism better. Nutrients and their metabolites act as building blocks and fuel sources of the cell structure, as the direct modifiers of protein function, the inducers and repressors of gene expressions Studies have confirmed that nutrition affects a persons’ thinking ability, their behavior, health and all the other factors that affect their ability of performing tasks. Research has also proved that diets high in saturated and trans fats negatively impact memory and learning. Access to proper nutrition in school-aged children aid cognitive development ; improve their cognitive ability, concentration and energy levels and children who do not have access to proper nutrition can affect their development and concentration levels. A study conducted on students in the 5th grade, by Florence in 2008, showed that children who consumed proper nutrition did better on tests than the ones who did not (5) A 2012 study conducted by Li & O’Connell showed that 5th graders who ate more fast food did worse in a math and reading test than the ones who ate much less fast food.

When a woman is pregnant or is lactating, the body needs additional nutrients so as to fulfil the needs of the baby as well as her own body. When they fail to obtain the required amounts of nutrients,
I.e. vitamins A, B complex, C, E, can lead to chronic diseases which may show up much later in the lives of their children (6). Consuming adequate amounts of folate is important to prevent neural tube defects during pregnancy (7).

Elderly people (age 65 and above) are particularly susceptible to malnutrition, the symptoms of which include frequent falling, infections occurring often, loss of energy and thus mobility, confusion and poor wound healing ability of the body. Older people are at a greater risk as the risk of morbidity and mortality due to malnutrition increases with age. Some of the common conditions found in malnourished old people are cardiovascular diseases, hypertension, obesity and diabetes. Obesity is most prevalent in the world and the numbers continue to rise (8).

To summarize, proper nutrition is very important as it helps to maintain a healthy body, keep your body free from diseases and reduce the risk of future diseases.

Balanced diet

In the past couple of decades, the problem of obesity has continued to rise throughout the world. Theoretically, a balanced diet is the only possible solution for this problem. In practice though, a combination of a balanced diet and an active lifestyle is required. This combination reduces the risk of very serious health problems like obesity, cancer, cardiovascular diseases, etc. A diet that contains all the nutrient classes (carbohydrates, vitamins, minerals, proteins, fibers) in specific proportions according to the age, sex, weight of a person is known as a balanced diet. The proportion of these categories differs from person to person. Often, we do find a generalized percentage for each age group and sex but the precise quantities differ from person to person. Our diets also provide us with antioxidants, phytochemicals, nutraceuticals which are essential for the body to carry out its processes properly. As a blanket rule, a balanced diet should have 60-70% carbohydrates, 10-12% proteins and 20-25% fats.

Figure 2: Balanced diet

In addition to preventing chronic diseases, a balanced diet is also essential for ensuring a healthy development in children and adolescents. Getting the balance between the proportions of the nutrient classes is very important – too much or too less can potentially be harmful (9).

In order for the body’s tissues and organs to work effectively, a proper nutrition is extremely important. The lack of proper nutrition makes the body susceptible to infection, diseases and fatigue. In children, a poor diet poses a risk of developmental problems and thus a poor academic performance. Prolonged periods of poor nutrition gets the body habituated to it and the person gets accustomed to bad eating habits persisting throughout their lives. The current trends of rising obesity in the United States of America is a perfect case study of effects of poor diets and an inactive lifestyle.

Balanced diets are essentially low in unnecessary sugars and fats, high in minerals, vitamins, proteins and fibers. The food groups in a balanced diet are:

- Carbohydrates: Carbohydrates are the primary source of energy of the body. They comprise 60-70% of the meal (around 310 grams). Rich sources of carbohydrates in a diet are rice, potatoes and wheat.
- Proteins: Proteins are the building blocks of...
Therefore to have a healthy living, a person should be mindful of the diet and ensure it is a balanced diet.

Deficiency Disorders

01. Iron Deficiency

Iron deficiency is also known as ‘anemia’. Iron deficiency occurs when there is an imbalance of the amount of iron going inside, stored and lost from the body. This imbalance affects the production of erythrocytes which is harmful for the body. Mainly, a majority of people in underdeveloped countries are affected by this deficiency, although the mortality is low.

About half of the iron content in our body is in the hemoglobin. Iron demand in the body is generated by:

01. Oxygenation of the tissue
02. Turnover of erythrocytes, and
03. Loss of erythrocytes due to hemorrhage.

Everyday about 20 ml old erythrocytes (Red Blood Cells) are cleared and 20 mg of iron present in those cells is reused for the production of new Red Blood Cells (RBCs). In anemia, the half-life of RBCs in the blood becomes shorter and the amount of iron present in the cells reduces. Anemia is characterized by less saturation of iron in the transferrin available. Transferrin is the immediate available source of iron available for RBCs. Transferrin gets its iron from:

01. The gut – from the food that we consume,
02. Old RBCs – the iron that get recycled,

- The liver – liver has stored ferritin iron.

In some regions of the world, more than 50%, up to 100% in some cases, children have anemia.

How is anemia recognized:

There are standardized range of values for normal, poor and very poor hemoglobin content in the blood. These values differ according to the age, sex, race, the environment the person lives in, etc. Currently, portable devices that identify the hemoglobin content by matching the color of the sample with the reference are being used. These devices have an accuracy of 95%.

Iron requirements per day:

- Adult male : 0.5-1 mg
- Adult female (menstruating) : 1-2mg
- Infants : 60μg/kg
- Children : 25 μg/kg
- During pregnancy (last 2 trimesters) : 3-5 mg/kg

Dietary sources of iron:

- Foods with high iron contents
Causes of anemia:
- Loss of blood:

1 ml of tightly packed RBCs contain 1 mg of iron. While stored, the iron starts depleting, in this situation if acute blood loss starts happening, the iron from food and from the old RBCs isn’t enough to compensate for the loss of iron from the blood loss. Hemorrhage is the leading cause of acute blood loss which often results in anemia. Blood loss during menstruation and hookworm infection affects majority of the population worldwide. About 2 ml of blood is lost by a healthy adult through feces every day. Other causes of blood loss are blood donation and nose bleeds. Nose bleeds can be a symptom of some serious underlying condition, which should never be taken casually.
- Malaria:

Majority of malaria cases, reported worldwide, are from the tropical regions. The hemoglobin iron is lost in the urine due to intravascular hemolysis. Various studies have emphasized on providing children living in tropical regions with iron supplements. Iron deficient diet and malabsorption:

Vegetarian and vegan diets contain sufficient amounts of iron which can prevent anemia, although the amount of iron stored in the person’s body is less. Iron supplements are an essential par of these diets to keep the iron levels balanced. Western diets lack in the amount of iron required during pregnancy. Diets containing meat have abundant iron content because the iron in them is more bio-available than the iron in foods of the vegetarian diets (5).

02. Iodine Deficient Disorder (IDD)

118 out of 195 countries battle with IDD. Similar to anemia, IDD is prevalent in developing countries. Iodine is important for our body’s functioning as it helps in the production of thyroid hormones: Triiodothyronine (T3) and Thyroxine (T4). Thyroid hormones are essential for the development of many organs, specially the brain. The deficiency of which affect the development of muscles and organs. Iodine deficiency is rather geographical than economic or social. Thus, people living in the mountains are prone to IDD.

Dietary sources of iodine:
- Iodine, in sea fish, vegetables – especially green leafy vegetables – grown on iodine rich soil, see weed are rich sources of iodine.
- Water and common salt are common sources of iodine.
- Cabbage, cauliflower and radish are vegetables that should be avoided because they contain substances called goitrogens which interfere with the synthesis of thyroxine.

Daily recommended intake:
- Infants: 110-130 mcg
- Children: 90 mcg
- Adult male: 120-150 mcg
- Adult female: 120 mcg
- During pregnancy: 220 mcg
- During lactation: 290 mcg

Deficiency disorders:
- Fetal iodine deficiency:

If women, during their pregnancy do not get the required amount of iodine, it can lead to the fetus being deficient of iodine. Fetal iodine deficiency, in severe cases, leads to still births, abortions and congenital abnormalities.
- Neonatal & childhood hypothyroidism:

Research shows that cord blood of every 10 new borns rom Tarai region of Uttar Pradesh were hypothyroid at birth. In spite of the adaptive enlargement of the thyroid gland, 30% of the subjects were functionally hypothyroid.
- Endemic cretinism:

Endemic cretinism refers to severe hypothyroidism during the developmental stages of the fetus and child. Some effects of it are mental retardation, deaf-mutism, squints, short stature.
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- Cretinoids:
  This is a less severe condition of endemic cretinism.
- Adult hypothyroidism:
  Adult hypothyroidism hampers human energy and thus performance and hence the economic growth of the country.

03. Protein Energy Malnutrition (PEM)

Malnutrition is a condition where there is an imbalance between the supply of nutrients and the energy demand of the body. Energy is required for the growth, development and maintenance of even the minutest of the body parts. Developing countries usually face PEM as majority of the population do not receive adequate food supply since their socio-economic conditions are such. Children are mainly affected by it. The year 2005 saw 20% of children below the age of 5, residing in developing counties, to be underweight; 32% were stunted. Malnutrition is assessed by measuring the mid-upper arm circumference (MUAC). MUAC acts as a proxy for weight and head circumference for height. MUAC is used when the exact weight and height data is not available. The severity of malnutrition is calculated by dividing the MUAC by the head circumference (1). The main manifestations of PEM are marasmus and kwashiorkor.

01. Marasmus:

Marasmus is more common than kwashiorkor. The depletion of subcutaneous fat stores is an indication of marasmus. Other symptoms include, muscle wasting and absence of edema. The bodies of people having marasmus gets accustomed to starvation which happens due to deprivation of calories and nutrition for extended periods of time. Marasmus is usually seen in children below the age of 5 years because their calorie needs are high and are more vulnerable to infections. Their skin becomes wrinkled and lose because of the fat loss. In severe case, it gives them a monkey-like or even aged appearance.

01. Kwashiorkor:

Kwashiorkor occurs due to inadequate protein but sufficient calorie intake. Generally seen in older infants or younger children. Older children in families having multiple children are often prone to kwashiorkor. As the younger child comes in, the older one gets off breastfeeding, usually before it is the right time. Thus, the protein intake of the child reduces. The characteristics of children with kwashiorkor are generalized edema, hypopigmentation of hair, normal weight for their age, distended abdomen and hepatomegaly. The dry skin progresses to a stage where it appears flaky and splits when stretched.

01. Marasmic Kwashiorkor:

This is characterized by the features of both marasmus and kwashiorkor. The children have muscle wasting, edema and stunted growth. They have skin and hair abnormalities and have an enlarged fatty liver.

Effects on different organ systems:

- Endocrine: Thyroid, insulin and growth hormones are mainly affected. Tri-iodothyroxine production and insulin production decreases. Growth hormone and cortisol levels increase. Glucose intolerance in developed.
- Immune: Degradation of the thymus, tonsils and lymph nodes. Loss of delayed hypersensitivity. Decrease in the levels of IgA and impaired phagocytosis.
- Gastrointestinal: Altered intestinal permeability, crypt hypoplasia and loss of disaccharides.
- Cardiovascular system: Cardiac output decreases, bradycardia and hypertension.
- Respiratory system: Thoracic muscle mass decreases, metabolic rate decreases, electrolytic imbalance, minute ventilation decreases.
- Neurological system: Number of neurons decreases, synapses decreases, dendritic arborizations decreases, brain size reduces and brain growth is slowed.
- Hematological system: Normochromic anemia can occur but blood clotting is preserved.
04. Calcium and vitamin D deficiency:

Vitamin D is essential for adjusting the body to changing demand and supply of calcium. Vitamin D is important for people in the developing countries because of their low calcium intake. Factors like pollution and overcrowding contribute to low vitamin D in children and infants. Infant and adolescent girls are at a high risk of being vitamin D deficient. People go long periods without consuming foods that are sources of vitamin D and their bodies adapt to the low intakes of the vitamin. This adaption is characterized by reduced excretion of renal calcium and increased intestinal absorption. Severe deficiency of vitamin D or calcium results in rickets.

The main function of vitamin is to aid bone development. Vitamin D also has immune functions. In children who are vitamin D deficient but who consume diets which have enough amount of calcium, only 1/3rd of the calcium is absorbed. People with vitamin D deficiency have their intestinal absorption of calcium reduced to 10-15% of the intake. In conditions where the calcium intake of the body is low, vitamin D is required because as it is important for the absorption process (10) Lactating mothers need vitamin D supplements to keep the concentration of vitamin D in the breastmilk adequate for the infant’s.

Rich sources of dietary calcium are dairy products. The average per capita intake of calcium in developed countries was found to be 850 mg/day and 344 mg/day in developing countries. The difference was because of the intake of calcium from meat consumed. The recommended daily allowance of calcium is 700-1300 mg/day for ages 1-18, and 500-1100 mg/day for above 18 years of age.

05. Vitamin A deficiency (VAD):

This is another public health issue faced by the developing countries. The main causes of it are the social, economic and cultural limitations, poor absorption by the body and insufficient intake of the vitamin. Other factors which worsen the situation are lack of education, absence of new legislation, poor sanitation, improper enforcement of existing laws. In severe cases, VAD leads to xerophthalmia (xerophthalmia is the most common cause of preventable blindness among children). High prevalence of this deficiency leads to increased morbidity and mortality in children, pregnant women and infants. Beta-carotene as well as it’s precursor are synthesized in plants whereas retinol comes from tissues like liver. In South Asia, about 44-50% children below the age of 6 years are affected by severe VAD (WHO, Global database on vitamin A deficiency, 2009). 85% of the total South Asian children having xerophthalmia live in India (WHO, 2009). Some approaches that can turn out to be useful are: Eating a wholesome diet, vitamin supplements and fortification of food.

Etiology:

Vitamin A is necessary for the proper functioning of the visual system, normal cell differentiation, body’s resistance against infection, RBC production and proper functioning of the reproductive system.
VAD is common in populations who consume vegetarian or plant-based diets (Lancet, 1995). In infants, the failure of consuming colostrum affects the levels of vitamin A. Consumption of foods that have poor bioavailability of beta-carotene is the main cause of VAD in people consuming plan-based diets.

India VAD scenario:

India has the highest amount of cases of VAD among all South Asian countries, and hence also has the highest mortality rate (33,000 deaths annually). India represents a wide variety of cultural, social, economic and environmental settings thus, show a variety of VAD severity. Although, the government of India has been putting a lot of money and efforts to put into place measures and programs to curtail VAD the problem hasn’t reduced as expected (Asian Dev Rev., 1999). One such program is vitamin A supplementation at a six month interval from the age of 9 months till 5 years.

Recommended daily allowance of vitamin A:

Vitamin A is expressed as Retinol Equivalents (RE). 1 RE = 1 μg retinol = 6 μg beta-carotene. The RDA for an a fully grown man is 1000 RE while for a female it is 800 RE. This requirement, however, increases in pregnant women and lactating mothers.

Prevention

01. Iron Deficiency Anemia:

   a) Iron fortification:

Mid-day meals provided in Indian government schools are usually fortified with vitamins and minerals. Children, especially girl students are given iron supplement pills. All these measures are put into place to reduce anemia (11) Pregnant and lactating women are also always given iron supplements (12)

   b) Delay in the umbilical cord clamping:

   Delaying the cord cutting by 5 mins has shown to add about 170 ml of blood in the new born (Usher et. al., 1963). This has proved to prevent anemia development in the first six months of the infant’s life. The infants who had undergone delayed (> 3 min) clamping had ferritin levels above 20 μg/ L. This procedure in underdeveloped communities, as it incurs little, if an, additional expense.

02. Iodine deficiency disorder (IDD):

1. Fortification:

   a) Salt: it is a unique advantage among other micronutrient supplements that it requires no change in dietary habits. The goal in prevention of IDDs is Universal Salt Iodization (USI). Salt is iodized in various ways, including dry mixing, drip, or spray techniques. The use of plastic bagging has reduced iodine losses between manufacture and consumer. A customary level of fortification of salt is in the range of 25-50 mg iodine/ kg of salt. there should be a maintenance of the level of added iodine within safe and effective limits.

   b) Iodinated water: A silastic cylinder containing iodine is used in bore holes to achieve success in raising iodine intake in the community. Reduction in IDDs was reported, but some disuse of this method occurs because of mechanical, legal and monitoring problems.

2. Supplementation:

   a) Drops and tablets of iodine: Iodine as sodium iodide was given to school children twice yearly prevents goiter. Drops of Lugol’s solution and iodine salts’ tablet disguised with chocolate have also been used in schools.

   b) Iodinated oil: In late 1950s, in New Guinea iodinated poppy seed oil has been widely used in the prevention of IDDs. A single dose was taken for the fulfilment of the requirement for one or more year. These
Dietary intake of vitamin A is increased by a viable strategy of fortification of food with vitamin A. Fortification of sugar 30 years back was done by central and south America to control VAD. Fortification of vegetable oil with vitamin A is another approach to achieve desired results. There is a mandatory fortification of cooking oils in developing societies to combat VAD; eg. In India all oils must be fortified at 20 IU/g. Cereal-based products like cookies, cakes and pastries containing fat up to 20-30% are also fortified with vitamin A. Bio-availability and appropriate levels are substantial factors to improve nutrient status among population with very little risk of adverse effects (11).

Supplementation is a very effective method of providing vitamin A in low-income regions of the world. 20,000 IU of vitamin A supplements are given to children below the age of 5 or 100,000 IU vitamin A to the ones aged 6-11 months (WHO, 1997). There has been a 23% reduction in the Indian mortality rate because of the vitamin A supplementation (13).

Education of mothers is very important to detect the deficiency early on. Mothers if taught the signs and symptoms of VAD can be really effective in identifying it in its early stages and thus controlling it early on. Also the knowledge of the foods to be eaten helps lessen the risk of VAD development.

The World Health Organization has devised a 3 step approach:

01. **Fortification:**

02. **Supplementation:**

03. **Nutritional awareness:**

**Step 1 : Revive and stabilize**

This step comprises of primary, on field care. It includes treating any visible infection, prevention of further infection and all the measures taken to prevent further complications. This is done in the first week of patient care. This week is usually the most critical period. The calorie intake is restricted to 60-80% of the requirement of the patient’s requirement. Refeeding syndrome can be prevented by giving phosphate and thiamine.

**Step 2 : Rehabilitation**

This starts from the second week of the patient care till the seventh week. This is only to be started when all acute complications have been resolved. Rehabilitation is done in order to treat occult infections, complete vaccination, increase calorie intake and stimulate psychomotor activity. Children having kwashiorkor need 120-140% of their required caloric intake in order to reach the desired weight and their desired growth.

**Step 3 : Follow up**

After discharge, a follow up is prescribed to avoid relapse. This is helpful in promoting breastfeeding, vitamin and mineral supplementations and personal hygiene.

**Step 2 : Calcium and vitamin D deficiency:**

01. **Exposure to sunlight**

Vitamin D is synthesized in the skin by the exposure to sunlight, as sunlight contains UV-B light. The effects on the vitamin D synthesis reduces with the use of sunscreen and darker pigmented skin.
The American Academy of Pediatrics advises to keep children younger than 6 months of age out of direct exposure of sunlight. As this exposure has the potential to cause skin cancer.

Breastfeeding infants who do not get adequate vitamin D from supplements as well as the milk are at a high risk of developing vitamin D deficiency or rickets. Human milk, typically, consists of up to 25 IU/L vitamin D. Thus, all breastfeeding infants as well as mothers should be given vitamin D supplements (up to the first two months of life for infants).

Multi-vitamins are available with are a very good source of readily available vitamin D. Vitamin D powders are also available which can be put into water, milk and other foodstuff to fortify it. This can be given to the people who are at high risk of developing deficiency disorders – people who have a heredity condition of vitamin D deficiency or who have very low or negligible exposure to sunlight.

Conclusion

Nutritional deficiencies have since forever been an integral part of India. There are several reasons for the same, some of which are an improper diet, lack of awareness about nutrition and its importance, etc. Only recently have people started becoming aware that nutritional disorders, although fatal in severe cases, are completely preventable. The government is also actively implementing programs and measures to curb this problem. These programs have also been extremely helpful in propagating the information in the remotest parts of the country. Even though so much is being done, the desired results are not seen so far. There is a lot to be done.

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09. Crossref
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